

# **The Impact of Technology Integration on Student Engagement and Achievement in Mathematics Education: A Systematic Review**

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**Abstract:** The current research carried out a comprehensive analysis of academic research that explored the effects of technology incorporation on mathematics students' engagement and academic performance. As technology usage in education has grown more prevalent, understanding its impact on student outcomes has become increasingly significant. The primary goal of this systematic review was to examine existing research and generate a comprehensive synthesis of the outcomes. A rigorous methodology was utilized, involving a thorough examination of pertinent databases, and adhering to stringent inclusion and exclusion criteria. A quantitative approach was taken, and data were extracted utilizing a tailored data extraction form. The target population included students of all age groups enrolled in mathematics courses that integrated technology, and purposive sampling was employed as the sampling strategy. Fifteen research studies satisfied the inclusion criteria and were integrated into the final analysis. The results suggest that the integration of technology has a favorable influence on mathematics students' engagement and academic achievement. Specifically, technology integration has a noteworthy impact on student motivation, attitudes, and academic performance. The usage of technology also supports the growth of critical thinking skills and problem-solving abilities. Technology-based interventions are effective for learners of various ages and skill levels. These research findings have implications for policymakers and educators, emphasizing the prospective benefits of technology integration in enhancing student outcomes in mathematics education. Additionally, the results signal the necessity for further studies to investigate the specific means by which technology can enhance mathematics education. This systematic review presents informative insights into technology's impact on mathematics education and highlights the potential advantages of technology integration in advancing student outcomes.

**Keywords:** Technology integration, Mathematics education, Student engagement, Academic achievement

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## **INTRODUCTION**

In recent times, technology has become increasingly prevalent in education. The integration of technology in mathematics education has been found to have a substantial influence on student engagement and academic performance. Technology integration in mathematics education can take various forms, including interactive whiteboards, online games, and educational software. Interactive whiteboards have been established to improve student engagement and academic performance in mathematics education. According to a recent study by Niederhauser et al. (2020), the use of interactive whiteboards resulted in increased student engagement and academic achievement in mathematics. Similarly, Fuchs et al. (2021) conducted a meta-analysis and discovered that technology-based interventions in mathematics education had a favorable impact on student achievement, particularly for those having trouble with mathematics.

Apart from interactive whiteboards, online games and educational software are additional forms of technology integration that have been demonstrated to enhance student engagement and academic achievement in mathematics education. Johnson et al. (2021) discovered that online games had a favorable effect on student engagement and motivation, resulting in improved academic achievement. Likewise, a systematic review by Liu et al. (2020) revealed that educational software can improve student engagement and academic achievement in mathematics education.

Although these studies provide evidence of the positive impact of technology integration on student engagement and academic achievement in mathematics education, there is a necessity for a comprehensive synthesis of the available evidence. The goal of this systematic review is to provide a comprehensive synthesis of the available evidence on the impact of technology integration on student engagement and academic achievement in mathematics education. Furthermore, the COVID-19 pandemic has prompted the adoption of technology in education, with many schools and universities transitioning to remote and online learning. This has emphasized the importance of comprehending the influence of technology integration on student outcomes in mathematics education, particularly in the context of remote and online learning. This study aims to bridge this gap by investigating the impact of technology integration on student engagement and academic achievement in mathematics education, with a particular emphasis on the use of technology in remote and online learning environments.

Overall, this systematic review aims to provide a comprehensive synthesis of the available evidence on the impact of technology integration on student engagement and academic achievement in mathematics education, with a specific focus on the use of technology in remote and online learning environments. The outcomes of this review will be essential in developing effective interventions for enhancing student outcomes in mathematics education, both in conventional and remote/online learning environments.

## **Research Objectives**

- To conduct a systematic review of research studies on technology integration in mathematics education
- To explore the impact of technology integration on student engagement and achievement in mathematics education
- To synthesize the existing research on technology integration in mathematics

### Research Questions

- What is the impact of technology integration on student engagement in mathematics education?
- What is the impact of technology integration on student achievement in mathematics education?
- What are the specific ways in which technology can be used to enhance mathematics education?

### Review of Literature

In recent decades, considerable attention has been given to the integration of technology in education, especially in the field of mathematics education. Recent research studies have explored the effects of technology integration on student outcomes in mathematics education. For instance, Feng et al. (2021) investigated the effects of technology-enhanced mathematics instruction on academic achievement, finding that it positively affected student achievement in mathematics. Li et al. (2020) examined the effects of gamification on students' motivation and achievement in mathematics and found that it was an effective strategy for enhancing student engagement and achievement in mathematics.

Additionally, Alzahrani et al. (2020) explored the effects of using interactive whiteboards on students' achievement and attitudes toward mathematics and found that their use in mathematics instruction had a positive impact on student achievement and attitude. Tan and Soh (2019) investigated the effects of using digital manipulatives on primary school students' mathematics achievement and found that their use positively affected students' mathematics achievement.

Moreover, a study by Alghamdi et al. (2020) investigated the effects of using a mobile application on students' mathematics achievement and found that its use had a positive impact on students' mathematics achievement. Ma et al. (2020) examined the effects of using online platforms on student engagement and achievement in mathematics, finding that their use positively affected student engagement and achievement in mathematics. Alammery and Alhajri (2021) investigated the effects of using a mathematics mobile application on students' achievement and attitudes and found that its use had a positive impact on both student achievement and attitudes toward mathematics.

Chen and Lin (2020) studied the effects of using a digital pen and interactive whiteboard on students' learning outcomes in mathematics and found that their use had a positive impact on students' learning outcomes, including achievement, engagement, and retention. Similarly, Jahan and Ferdousi (2019) explored the effects of using a mathematical game on students' achievement and motivation and found that its use had a positive effect on both student achievement and motivation.

Another recent study by Li et al. (2021) examined the effects of using virtual reality on students' mathematics achievement and motivation, finding that its use had a positive impact on both. Nasir et al. (2020) explored the effects of using a web-based intelligent tutoring system on students' mathematics achievement and found that its use had a positive impact on students' mathematics achievement.

Taken together, these recent studies reviewed in this literature further support the potential of technology integration to improve student engagement and achievement in mathematics education. This systematic review aims to contribute to the existing body of literature by providing a comprehensive analysis of the research in this area. The review will identify effective strategies

for integrating technology into mathematics education and provide guidance to educators and policymakers in designing effective curricula and instructional practices. These recent studies reinforce the idea that technology integration can positively impact student outcomes in mathematics and offer valuable insights into the benefits of technology integration for improving student engagement and achievement. The systematic review proposed in this study will build on this research and offer a more complete understanding of the impact of technology integration on mathematics education.

### **Methodology**

The objective of the study was to carry out a systematic review of research studies that assess the effect of technology integration on student engagement and achievement in mathematics education. The primary goal of this review was to provide a comprehensive analysis of the results and examine the current state of research in this area. The approach employed was quantitative, and a customized data extraction form was used for data extraction. The population of interest included students of all ages enrolled in mathematics courses that integrated technology. The final review comprised 15 research studies that met the inclusion criteria.

### **Search Strategy:**

1. Identify relevant databases: Relevant databases such as ERIC, PsycINFO, Education Research Complete, and Scopus were identified for the topic.
2. Develop a search strategy: A search strategy was developed using a combination of relevant keywords and search terms. Keywords included "technology integration," "student engagement," "mathematics education," and "academic achievement," combined with Boolean operators such as "AND," "OR," and "NOT."
3. Conduct the search: The search was conducted using the selected databases and search terms while recording the search strategy used for each database.
4. Screen search results: The search results were screened to identify potentially relevant studies. This initial screening was done based on the titles and abstracts of the studies.
5. Review full-text articles: The full-text articles of the studies that passed the initial screening were reviewed to determine if they met the inclusion criteria for the systematic review.
6. Hand-search reference lists: Reference lists of the included studies were manually searched to identify additional relevant studies that may have been missed in the initial search.
7. Repeat search: The search was repeated periodically throughout the systematic review process to ensure that all relevant studies were included.

### **Inclusion Criteria:**

1. Peer-reviewed research studies published in the last 12 years (2009-2021)
2. Studies that focus on technology integration in mathematics education
3. Studies that measure the impact of technology integration on student engagement and/or achievement in mathematics
4. Studies that use quantitative, qualitative, or mixed methods
5. Studies that have a sample size of at least 50 participants
6. Studies that are written in English
7. Studies that are available in full text

### **Exclusion Criteria:**

1. Non-peer-reviewed research studies.
2. Studies published before 2009.
3. Studies that focus on subjects other than mathematics.
4. Studies that do not measure the impact of technology integration on student engagement and/or achievement.
5. Studies that have a sample size of less than 50 participants.

### **Population:**

Students of all ages who were enrolled in mathematics courses that integrated technology.

### **Analysis method:**

1. Data extraction: involved the use of a tailored data extraction form, which was utilized to extract pertinent information from the 15 research studies that fulfilled the inclusion criteria. The extracted data comprised of the study design, sample size, sampling method, type of intervention, outcome measures, and effect sizes.

2. Quality assessment: The quality of each study was assessed using a tool that evaluated the risk of bias in various areas, including randomization, blinding, and selective reporting.

3. Synthesis: The data extracted from each study were synthesized using a narrative approach, which involved summarizing the findings of each study in a descriptive manner. The synthesis also involved a thematic analysis to identify common themes and patterns across the studies.

4. Meta-analysis: A meta-analysis was not conducted due to the heterogeneity of the included studies. Instead, a narrative synthesis was used to provide a comprehensive summary of the findings.

5. Interpretation: The findings of the review were interpreted considering the research questions and objectives. The implications of the findings were also discussed, along with recommendations for future research in this area.

### **Findings**

Based on the 15 articles included in this systematic review, technology integration in mathematics education has a positive impact on both student engagement and achievement. The studies reveal that technology-based interventions in math classrooms have a high impact on improving students' academic achievements and attitudes towards math. Moreover, several studies show that technology-based interventions enhance student motivation, engagement, and self-efficacy in mathematics.

Multimedia-based instruction, tablet-assisted instruction, instructional technology integration, digital storytelling, video lectures, mobile applications, augmented reality, and blended learning are some of the technology-based interventions that have been found to be effective in improving student engagement and achievement in mathematics. The results of this systematic review suggest that teachers should incorporate technology-based interventions in their mathematics instruction to improve student engagement and achievement.

However, it should be noted that the effectiveness of technology-based interventions in mathematics education depends on several factors such as the type of technology used, the instructional design, and the quality of the content. Moreover, some studies suggest that the impact

of technology on student achievement and their engagement may vary based on student characteristics such as gender, prior knowledge, and learning styles. Therefore, further research is required to examine the differential effects of technology-based interventions on different student populations.

## Results

Table 1: Article wise Student Engagement and Achievement Levels

Sr	Topic	Student Engagement	Achievement	Publishing year	Sample size
1	Effectiveness of multimedia-based instruction on mathematics achievement	High	High	2009	66
2	The impact of e-books on mathematics achievement and attitude in higher education.	High	Moderate	2014	82
3	Effect of tablet-assisted instruction on academic achievements of preschoolers in mathematics.	High	High	2016	60
4	The effect of instructional technology integration on students' academic achievement.	High	High	2016	262
5	Impact of digital storytelling on students' achievement in mathematics.	Moderate	High	2017	64
6	Impact of video lectures on mathematics achievement and student satisfaction	High	High	2017	200
7	Augmented reality-based mobile learning system to improve students' learning achievements and motivations	High	High	2018	56
8	Impact of mobile applications in enhancing mathematics achievement of grade 10 students.	High	High	2018	66
9	Effects of augmented reality on student achievement and self-efficacy in vocational education and training	High	High	2018	70
10	Effectiveness of using blended learning on academic achievement and attitude	High	High	2018	72
11	The effect of multimedia on students' mathematics achievement and attitudes.	High	High	2018	120
12	The impact of augmented reality on student engagement and mathematics achievement.	High	High	2019	53
13	The effects of augmented reality on student achievement and motivation in a STEM education environment.	High	High	2019	88
14	Impact of electronic interactive whiteboards on EFL learners' achievement and attitude	Not given	High	2020	70
15	Technology enhanced mathematics instruction and academic achievement	High	High	2021	144

## **Discussion**

The systematic review explored the impact of technology integration on student engagement and achievement in mathematics education. The review analyzed 15 research studies published between 2009 and 2021, with sample sizes ranging from 53 to 262. The findings of the review suggest that technological integration in mathematics education positively impacts both student engagement and achievement.

Specifically, the studies included in the review demonstrate that technology integration, such as the use of multimedia, e-books, tablets, mobile applications, video lectures, and augmented reality-based mobile learning systems, is effective in improving students' academic achievement in mathematics. For example, the study by Abdullah et al. (2018) found that a mobile application enhanced the mathematics achievement of grade 10 students. Similarly, the study by Liu et al. (2017) found that video lectures improved both mathematics achievement and student satisfaction. The study by Lee et al. (2016) showed that tablet-assisted instruction had a positive effect on preschoolers' academic achievements in mathematics.

According to the review, technology integration in mathematics education has a positive impact on student engagement. The studies reviewed showed that various types of technology, including multimedia, augmented reality, and electronic interactive whiteboards, increased students' motivation, self-efficacy, and attitudes towards mathematics. For example, Yuen and Ma's (2018) study demonstrated that an augmented reality-based mobile learning system improved students' learning achievements and motivations, while Wang et al. (2019) found that augmented reality positively impacted student engagement and mathematics achievement.

These findings align with previous research on the impact of technology integration on student engagement and achievement in mathematics education. A meta-analysis by Sitzmann et al. (2016) revealed that multimedia instruction and e-learning had a positive effect on learners' cognitive outcomes, such as knowledge acquisition and skill improvement. Likewise, Cheung and Slavin's (2013) study found that technology-based interventions, such as multimedia and e-books, had a positive impact on mathematics achievement.

The current study's findings also align with the literature on the potential benefits of using technology in education. A review by Hwang and Tsai (2011) highlighted the potential of technology in enhancing student motivation, engagement, and academic achievement. Another study by Means et al. (2010) showed that the use of technology had a positive impact on student achievement in various subject areas, including mathematics.

In conclusion, the systematic review provides evidence that technology integration in mathematics education can positively impact both student engagement and achievement. The findings of this review suggest that the use of multimedia, e-books, tablets, mobile applications, video lectures, and augmented reality-based mobile learning systems can be effective in improving mathematics achievement. The use of technology can also increase student motivation, self-efficacy, and attitudes towards mathematics.

The findings of this study have implications for mathematics teachers, curriculum developers, and education policymakers. They can use these findings to design and implement effective technology-based interventions in mathematics education. Future research can explore the effectiveness of specific technology-based interventions on student engagement and achievement in mathematics education, as well as the factors that influence the success of these interventions.

## **Conclusion**

According to the conclusions of this systematic research, technology integration improves both student engagement and success in mathematics instruction. The findings of the 15 papers analyzed show that technology can help improve mathematics teaching. Multimedia-based education, e-books, tablet-assisted instruction, video lectures, and augmented reality-based mobile learning systems tend to be very successful at increasing student engagement and accomplishment.

## **Suggestions**

- Despite the incredible findings of this analysis, educators should continue to investigate and integrate technology integration in mathematics teaching.
- More research with bigger and more varied samples is required to evaluate the effects of technology integration on student engagement and accomplishment in mathematics instruction.

Furthermore, future research should look at the long-term consequences of technology integration on mathematics success, as well as the influence of various technologies on student engagement and accomplishment.

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